The U.K. Radiocommunications Agency and CellularVision Concur: LMDS is Not Viable in the Frequency Bands Above 40 GHz

A Review of: "UK Radiocommunications Agency comments on CellularVision submission to FCC NPRM dated 30 January 1995 Entitled 'LMDS is not viable in the frequency bands above 40 GHz' " (dated 7 March 1995)

Prepared by

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for

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I. Introduction

This document is a review of the comments of the U.K. Radiocommunications Agency (RA) in its March 7, 1995 Comments to the Commission in the 40 GHz NPRM (copy attached at Tab 1). Key statements of the RA are reviewed in the context of CellularVision's Comments and Reply Comments in the same 40 GHz NPRM. With regard to the important issues in considering LMDS viability above 40 GHz, the RA and CellularVision are in agreement even where the "numbers" differ slightly. Below, the key issues are reviewed and the positions of the RA and CellularVision are set forth to demonstrate the alignment of the views of the RA and CellularVision. Taken together, the common views of the RA and CellularVision demonstrate that LMDS is not viable in the bands above 40 GHz in the U.S.

II. RA Acknowledges that 40 GHz MVDS Video Distribution is only in the Developmental Stage

The RA notes in its comments: "...what *works*...at 28 GHz...*can be made to work* at 40 GHz." (p.1, emphasis added).

While this blanket statement must be considered to be inconsistent with the simple observation that design and implementation of microwave and millimeter-wave hardware is more difficult and expensive as the frequency increases, it is more interesting to note the verb tenses in the RA statement. Clearly, the RA acknowledges that 28 GHz LMDS is a reality today, while 40 GHz MVDS is only in the developmental stage.

It is equally clear to any party involved in the design of hardware components for operation in the microwave and millimeter-wave bands that as frequency increases, design for equivalent performance and cost becomes more difficult if not impossible.

As advances in technology allow improved performance at higher frequencies, additional advantages also accrue at the lower frequencies so that the advantage of utilizing 28 GHz for LMDS will always remain. Additionally, as has been noted more than occasionally, "time is money"--28 GHz LMDS is a reality today, while 40 GHz MVDS is still in the developmental stage. A comparison of system components available at 40 GHz and 28 GHz, regardless of when the comparison is made, will reveal that the 40 GHz components are more costly, have lower efficiencies and are available later in time than their 28 GHz counterparts.

Further, it should be noted that some parties in the 40 GHz NPRM assume that the necessary transmitter power amplifiers and receiver low noise amplifiers, among other components, are available today at both frequencies with equivalent performance characteristics and prices. Both the RA and CellularVision dispute these assumptions.

These parties, in comments to and in Ex Parte visits with the Commission have stated that 40 GHz MVDS equipment will be available in production quantities by August 1995 (Teledesic Ex Parte Presentation, March 16, 1995, p. 7)(copy attached at Tab 2). The potential availability of 40 GHz MVDS equipment is irrelevant. As the RA has noted (and as described below in Sections III and IV of this paper), 40 GHz MVDS is economically inferior to 28 GHz LMDS based solely on a comparison of the transmitter coverage areas of the systems--40 GHz MVDS is not economically viable in the U.S. Valid concerns about the cost and performance of 40 GHz components only magnify this conclusion.

III. RA Supports the CellularVision View--Reduced Transmitter Coverage at 40 GHz has a Severe Technical and Economic Impact on System Viability in the U.S.

The RA states "It is our view that 40 GHz will be made to work within Europe and that it possesses very similar attributes to a 29 GHz system, albeit with reduced coverage due to rain and atmospheric absorption." (p. 5).

The RA also states "...it is not in doubt that larger coverage areas are possible at lower frequencies than 40 GHz, for example at 29 GHz, due primarily to the increase in atmospheric losses and rain attenuation with increasing frequency." (p. 1).

Other statements by the RA underscore the conclusion that 40 GHz MVDS systems are not suited for application in the U.S. For example, the RA states that "(i)t has always been recognised that the size of MVDS cells at 40 GHz is *considerably reduced* during rain fades. Therefore *40 GHz is better suited to lower rain rate climates*" (p. 3, emphasis added). While CellularVision acknowledges that there are some "low rain rate" areas in the U.S., it is also true that they are dominated by the very areas LMDS is not intended to serve--large, sparsely populated, economically unviable areas.

CellularVision concurs with these RA views, as presented in its numerous previous filings in the 40 GHz NPRM. It should be noted that the penalty due to moving from 28 GHz to 40 GHz is even more severe in the United States than in Western/Northern Europe. The conclusion that 40 GHz MVDS is technically and economically viable in (at least part of) Europe rests on a specific rainfall assumption that cannot be utilized for continental and subtropical climate zones such as those in the U.S. In continental and subtropical climate zones the penalty is so severe as to jeopardize the viability of the system.

IV. The RA's "Apples-to-Apples" Comparison Demonstrates The Severe Cost Impact of Operations at 40 GHz

The RA notes that in moving from 28 GHz to 40 GHz, the range of the MVDS system in the drizzle-climate European region is reduced from 5.35 km to 3.4 km. (p. 2). As Table 1 shows, this results in an increase in the number of transmitter sites necessary to cover a given geographic area by a factor of 2.5. Even more drastic is the increase in number of transmitter sites required to cover a given geographic area for 40 GHz MVDS relative to 28 GHz LMDS, as shown in Table 1. It can be seen that, since the coverage area of the 28 GHz LMDS transmitter is 8 times larger than for the 40 GHz MVDS transmitter, the 40 GHz MVDS system requires 8 times as many transmitters to cover a given geographic area as the 28 GHz LMDS system.

TABLE 1.
RELATIVE TRANSMITTER COVERAGE FOR 40 GHZ MVDS AND 28 GHZ LMDS USING RA DATA.

Frequency/System	Range	Transmitter Coverage	Relative Transmitter Coverage Area
41.5 GHz MVDS (Note 1)	3.4 km (cell diameter)	9.1 km^2	1.0 (RA baseline case)
29 GHz MVDS (Note 1)	5.35 km (cell diameter)	22.5 km^2	2.5
28 GHz LMDS (Note 2)	4.83 km (cell radius)	73.2 km^2	**8.0**

Note 1: These values are taken from the RA comments, page 2., and are for 99.9% availability with the MVDS 64° edge-fed sector horn antenna.

Note 2: These values are taken from the commercial LMDS system in New York and are for 99.9% availability with an LMDS omni-directional antenna.

It is striking to note that, by utilizing the RA's own statements, the 40 GHz MVDS system requires **eight times as many transmitter sites** to serve a given geographic area as the commercial 28 GHz LMDS system operating in New York. The penalty for operating at 40 GHz would be significantly worse if the RA data were to be normalized for equivalent rainfall assumptions.

An alternative viewpoint in the 40 GHz MVDS community indicates an even more severe MVDS disadvantage relative to 28 GHz LMDS. Philips Microwave, the only source known to be developing 40 GHz infrastructure equipment, notes that the range expected for 41.5 GHz MVDS is from 2 to 3 km at 99.7% availability (Philips Microwave, "Microwave Video Distribution Systems--The 1994 Position," November 16, 1994, p. 7 submitted in Teledesic Ex Parte presentation, March 10, 1995) (copy attached at Tab 3). Using the conservative value of 2 kilometers gives the results in Table 2.

TABLE 2.
RELATIVE TRANSMITTER COVERAGE FOR 40 GHZ MVDS AND 28 GHZ LMDS USING PHILIPS DATA.

Frequency/System	Range	Transmitter Coverage	Relative Transmitter Coverage Area
41.5 GHz MVDS (Note 1)	2.0 km (cell diameter)	3.1 km^2	1.0 (Philips baseline case)
28 GHz LMDS (Note 2)	4.83 km (cell radius)	73.2 km^2	**23.6**

Note 1: These values are taken from the Philips Microwave reference, p. 7, and are for 99.7% availability with the MVDS 64° edge-fed sector horn antenna.

Note 2: These values are taken from the commercial LMDS system in New York and are for 99.9% availability with an LMDS omni-directional antenna.

Thus, utilizing the experience of the only known 40 GHz MVDS infrastructure developer in implementing the RA-recommended 40 GHz MVDS system results in the need for **24 times as many transmitter sites** to serve a given geographic area as the commercial 28 GHz LMDS system operating in New York. It should be pointed out that if the availability of the cited 40 GHz MVDS system was adjusted to 99.9% to match the availability of the 28 GHz LMDS system, as opposed to the poorer 99.7% availability used in the European MVDS specification, and normalized for equivalent rainfall assumptions, the increase in the transmitter sites required would be even larger. Even using the other end of the span of possible ranges cited by Philips (3 kilometers), without these adjustments for availability and rain climate, results in the need for eleven times as many transmitter sites as in the commercial 28 GHz LMDS system in New York.

These observations illustrate the inefficiency of operating at 40 GHz as opposed to 28 GHz.

V. CellularVision and the RA / Philips Agree on the Numbers

CellularVision, in its comments and reply comments in the Commission's 40 GHz NPRM, has cited increases in the number of transmitter sites required to serve a given geographic area from 7.3 to 20. As documented immediately above, it can be seen that the RA and Philips data show a number from 8 to 23.6 for serving a given geographic area. Thus, **the RA, Philips and CellularVision appear to be in agreement** regarding the severe impact of moving from 28 GHz to 40 GHz in the U.S.

The RA also correctly has pointed out (p.3) that CellularVision carried a typographical error in its comments to the Commission (p. 13 , Appendix 2, CellularVision January 30, 1995 Comments in the 40 GHz NPRM). CellularVision noted in its comments that the 40 GHz MVDS link budget developed by the MVDS Working Group shows a range of 2 km (consistent with Philips Microwave's estimates) for a *rain rate of 2.1 mm/hr*. The correct value for a range of 2 km is a *rain rate of 7 mm/hr*, resulting in *rain attenuation of 2.1 dB/km*. The correct values for rain rate and attenuation yield the utilized MVDS Working Group result--a range of 2 km. Thus, the typographical error was not relevant to the analysis, and the MVDS Working Group's result correlates with the CellularVision result of 1.85 km (in CellularVision's January 30 Comments). The difference of 0.15 km is not consequential. CellularVision and the RA agree on the impact--from 7.3 to 20 (CellularVision) or 8 to 23.6 (RA/Philips) times as many transmitter sites are required to operate MVDS at 40 GHz relative to LMDS operations at 28 GHz for the same geographical area coverage. The cost impact renders 40 GHz systems unviable in the U.S.

CellularVision and the RA also agree on the need to "compare like with like" (p. 4). CellularVision has focused its assessments of 40 GHz viability in the U.S. on the current 28 GHz LMDS availability of 99.9% as opposed to the poorer 99.7% availability for 40 GHz MVDS and Hughes' Direct Broadcast Satellite (DBS) system. The RA has done likewise (p. 2). Hughes' DBS is a one-way, lower-availability, zero-local content, non-interactive service. 28 GHz LMDS is the opposite of all of these things. CellularVision and the RA have been direct in comparing 28 GHz LMDS to 40 GHz MVDS on a consistent basis. A system video availability of 99.9% or better is required to support interactive, telephony and other symmetric services in LMDS. The 28 GHz LMDS system parameters that support this 99.9% availability for video service will support interactive, telephony and data service availability equal to that of existing wired telephony and data service delivery systems.

VI. 40 GHz MVDS Subscriber Antenna/Downconverter Costs are Prohibitive

The RA notes that the "whole concept of 40 GHz MVDS has been to keep the cost down by utilising existing standard low cost indoor satellite receiver decoders." (p. 4). CellularVision shares the concern of the RA regarding 40 GHz MVDS equipment costs. Philips Microwave has estimated the cost of the outdoor antenna/downconverter unit for the 40 GHz MVDS system to be as much as £130 (Philips Microwave, "Microwave Video Distribution Systems--The 1994 Position," November 16, 1994, p. 19). This equates to a cost of $217 and compares unfavorably to the CellularVision cost for the 28 GHz LMDS indoor/outdoor antenna/downconverter of less than $100. One reason for the two-to-one cost difference could be the dual downconverter in the 40 GHz MVDS unit. It is clear that in spite of an admirable "concept", the 40 GHz MVDS system carries prohibitive costs as compared to the cost of the 28 GHz LMDS system.

VII. The RA Points Out the Inability of The MVDS System to Reuse Frequency

The RA notes that the 40 GHz MVDS system offers a frequency re-use distance of 20 to 30 km (p.4), which pales in contrast to the ability to re-use frequency in every cell (9.7 km diameter typical) in the 28 GHz LMDS system. CellularVision has been emphatic in pointing out this severe deficiency in the 40 GHz MVDS system.

In pointing out the problems with frequency re-use at 40 GHz and above, the RA also makes two related points. First, the RA notes that for the first "operational trials" (p. 6) of 40 GHz MVDS in the Eurobell franchise, the 40 GHz MVDS system will be implemented "covering 33,000 (1/3) of the homes in the franchise area" (p. 2). Thus, only a third of the homes in the area are being served. This underscores the problem with frequency re-use in the 40 GHz MVDS system: If all available frequencies and interference isolation mechanisms are used in serving contiguous areas with multiple cells (e.g., four cells with each using one of four 40 GHz MVDS frequency sets), the frequency re-use constraint driven by the clear-air (no rain) shape of the transmitter coverage area in the 40 GHz MVDS system (re-use distance of 20-30 km) will likely preclude 40 GHz MVDS service for tens of kilometers in any direction from the original cells due to interference.

The RA also notes that the Eurobell franchise was granted in August, 1994--just eight months ago (p. 2), and three and one-half years after the first commercial LMDS license was issued. Furthermore, the RA speculates that "better (frequency) re-use will be possible in practice" (p. 4) and that the frequency re-use distances "will be modified as appropriate when the propagation results (from experiments?) are available." (p. 4). It is clear from these comments that 40 GHz MVDS is being considered in Europe in the future tense. Critical issues such as frequency re-use capacity are unresolved in the opinion of the RA.

Unfortunately, satellite proponents continue to set forth obvious misinformation regarding 40 GHz MVDS. A recent example of such blatant misleading statements is the assertion that "LMDS-type services are currently operating in Europe in the 41 GHz band, notes the (Global Satellite Communications) Coalition." ("Ka-Band Battle Rages," Satellite Communications Magazine, April, 1995, p. 16). This is simply false, as the RA has noted.

VIII. The RA Notes that the MVDS Recommendation "Maximizes" Frequency Re-Use and Also Notes the Benefits of LMDS on Many Fronts

The RA states that the "use of the 64° sector coverage antenna was chosen to *maximise* spectrum efficiency, providing essentially circular coverage from the edge of the coverage area while under rain faded conditions at the availability defined of 99.7% of time." (p. 4, emphasis added).

It is clear that the MVDS working group has gone to considerable effort to "maximize" the performance of the 40 GHz MVDS system. Even given this, the 40 GHz MVDS system is simply inferior (as the RA has quantitatively noted) to the 28 GHz LMDS system as demonstrated in Table 3.

TABLE 3.
SUMMARY OF RELATIVE PERFORMANCE OF 40 GHZ MVDS AND 28 GHZ LMDS.

Frequency/ System	Channel Service Capacity Per 2 GHz Allocation	Relative Number Transmitter Sites Required	Availability	Frequency Re-Use Distance
41.5 GHz MVDS	32	8 to 24	99.7%	20 - 30 km
28 GHz LMDS	100	1	99.9%	in every cell (10 km. typ.)

Even given the "maximization" attempted for the 40 GHz MVDS system, as Table 3 shows, 40 GHz MVDS is inferior to 28 GHz LMDS with regard to service channel capacity (by a factor of more than three); the number of transmitter sites required (where 40 GHz MVDS requires 8 to 24 times as many sites as 28 GHz LMDS); availability (where the unavailability of 40 GHz MVDS is triple that of 28 GHz LMDS); and in frequency re-use (by a factor of two to three in distance and four to nine in area). As the RA has noted by its own assessment, 40 GHz MVDS is hardly an attractive alternative to 28 GHz LMDS.

IX. The RA Recognizes that Spectral Efficiency Gains Would Have An Inescapable Cost

The RA points out that it uses 29.5 MHz channel spacing (versus the 20 MHz LMDS channel spacing) in its specification "to be compatible with existing low cost satellite indoor receiver decoders." (p. 4). The RA further notes that the "32 channel plan has been maximised to these parameters." (p. 4). These comments appear to be made in an attempt to point out that simply adopting the LMDS channel spacing would increase the channel capacity of the MVDS "concept of 40 GHz."

This option is set forth without addressing the well-known tradeoff that exists between the channel spacing and the coverage distance for the system--if the channel capacity is boosted by reducing the channel spacing, the Video Transfer Function in the demodulator will be degraded, resulting in a reduced range for the 40 GHz MVDS system below the already low values acknowledged by the RA. The reduced range would result in yet an additional increase in the number of transmitter sites for a given service area. Additionally, the cost of the transmitter equipment would increase in proportion to the number of channels added since the 40 GHz MVDS concept envisions a separate transmitter for every channel at every transmitter site.

Beyond accepting these additional costs, adopting the 20 MHz channel spacing used in the 28 GHz LMDS system would *still* leave 40 GHz MVDS at a two-to-one disadvantage in service channel capacity relative to 28 GHz LMDS because of the need to utilize two interference isolation mechanisms (frequency interleaving and polarization) to isolate adjacent cells in the 40 GHz MVDS system.

X. The RA and CellularVision Agree that 40 GHz MVDS Cannot Compete With Cable

The RA acknowledges the "recognition in our (its) report that 40 GHz MVDS cannot compete with cable" (p. 4) but notes that "there is the possibility of head-on competition to cable" (p. 5). CellularVision accepts this conclusion, and notes several related points. First, these comments carry forward the RA view that 40 GHz MVDS is only in the developmental stage if only by verb tense alone. Secondly, the RA recognizes that "competition with cable" involves issues of both cost and programming capacity. In the U.S., 40 GHz MVDS would fail to be competitive by both criteria, while the 28 GHz LMDS system is competitive today in both regards. The RA also notes that "Comparisons with equivalent radio systems at lower frequencies will always favour the greater coverage system" (p. 5). This is a clear acknowledgment of a key CellularVision assertion--that 28 GHz LMDS supports a wireless alternative competitive with cable under all conditions, while 40 GHz MVDS does not. It is encouraging that the RA and CellularVision agree.

Additionally, due to its high per-subscriber infrastructure and subscriber equipment cost, 40 GHz MVDS is apparently seen by Eurobell as an option only in low-population-density areas where cable infrastructure costs per subscriber would be prohibitively higher, resulting in no cable service. 40 GHz MVDS is apparently not an economically viable broadband alternative in cabled areas, unlike 28 GHz LMDS.

The Philips Paper reveals that the 40 GHz MVDS system is intended for "infill" in uncabled areas or other "sparsely populated areas." (Philips Microwave, "Microwave Video Distribution Systems--The 1994 Position," November 16, 1994, p.8). Because of this intended use for 40 GHz MVDS, the projected per-subscriber costs, which are already high enough to prohibit competition with cable in non-sparsely populated areas, do not include the cost of headend and distribution network facilities since the 40 GHz MVDS concept shares these assets with the cable network with which it cooperates. If these costs were included to determine the projected cost of a "stand-alone" 40 GHz MVDS system, the lack of ability to compete with cable would be even more obvious. 28 GHz LMDS, however, is an effective alternative to cable even with its own, separate headend and distribution network facilities.

The RA accurately states that "Technology improvements will increase the size of the coverage areas" (p. 5) for both 28 GHz and 40 GHz systems. The corollary to this observation is that as technology matures, 28 GHz systems will *always* hold an advantage (performance and cost) over 40 GHz systems. Future digital improvements can be applied in both bands and the advantages of operating at the lower frequency will be carried forward. It is also interesting to note that even massive improvements in technology (e.g., even two orders of magnitude (20 dB) in the system gain) would fail to increase the size of the 40 GHz MVDS coverage area in New York to the size of the *current* (*without* improvement due to any anticipated technology evolution) 28 GHz LMDS coverage area.

CellularVision believes that the RA has only recently recognized the advantages of "further development of the total cellular planning concept, as espoused by CellularVision" (p. 6). CellularVision welcomes the participation of the RA in advancing the LMDS technology as a viable, competitive wireless broadband alternative.

XI. European Acceptance of the MVDS Recommendation is in Dispute

The RA notes that it is "not able to speak for other European countries" (p. 2) and then goes on to represent that since 1990, regarding acceptance of the 40 GHz MVDS recommendation T/R52-01, "11 countries have accepted the recommendation, 8 countries plan to and 2 will not." (p. 2). This assertion is puzzling given the timely report that "the CEPT 40 GHz recommendation has been implemented in six countries, but no services utilizing this band have been deployed." ("European Coalition Pushes Wireless," Wireless International Magazine, March, 1995, p. 8).

XII. The RA Concurs with CellularVision--Digital Issues are Unresolved

The RA, in addressing the issue of digital MVDS, notes that the 40 GHz Working Group "is now addressing the requirements and specification for digital MVDS" (p. 2) and also that "No firm decisions have been made." (p. 2). Clearly the prospects for digital MVDS are unresolved in the opinion of the RA--and CellularVision agrees. In fact, as noted by the RA, the problems with frequency re-use and interference isolation in the 40 GHz MVDS system have resulted in consideration of the "return path" for interactive services in 40 GHz MVDS to be "overlaid in another frequency band or via twisted pair." (p.2). CellularVision concurs with this sobering view of the RA--that the 40 GHz MVDS system may not support in-band interactive services, unlike 28 GHz LMDS--which can indeed support this in-band, efficient mechanism for interactive, telephony and data services.

The Wireless International article also describes the findings of the Digital Microwave Multipoint Multichannel Propagation (DIMMP) consortium in characterizing emerging wireless activity in Europe by noting that "DIMMP's initial findings showed that 100 percent of the countries responding (to the DIMMP survey) have not made decisions regarding digital MMDS; only three countries appear to be investigating the technology..." ("European Coalition Pushes Wireless," Wireless International Magazine, March, 1995, p. 8). Clearly, despite representations by the satellite interests to the contrary, consideration of digital wireless video distribution in Europe is in its infancy.

As is the case with other issues surrounding 40 GHz MVDS systems, the viewpoint of the RA and CellularVision regarding Digital MVDS is irrationally opposed by unsupportable claims by the satellite interests: Teledesic has claimed that Eurobell will deliver "full interactive service to 16,200 homes" and alludes to "service roll-out in 1996..." (Teledesic Ex Parte Presentation, March 16, 1995, p. 3). It is not clear how the digital "roll-out" will occur beginning in 1996 when the RA notes that "no firm decisions have been made" regarding an interactive (digital) 40 GHz MVDS system. Teledesic also misstates the capacity of the interactive "back-channel method" associated with the 40 GHz MVDS system in the same Ex Parte Presentation, when it is cited as "approx 64 - 640 KB/s" *(sic)* (Teledesic Ex Parte Presentation, March 16, 1995, p. 5) while the real values under consideration by the MVDS Working Group appear to be 6.4 - 128 kb/s (Philips Microwave, "Microwave Video Distribution Systems--The 1994 Position," November 16, 1994, p. 3).

The consideration of the "back-channel" by the 40 GHz MVDS working group indicates that 40 GHz MVDS is not envisioned as a fully-symmetric digital data path. The asymmetric 40 GHz digital MVDS plan is not an attractive digital pathway for interactive, telephony or data services. 28 GHz LMDS, however, can provide this fully symmetric service.

Likewise, in an extension of a troublesome pattern of continued misinformation, Teledesic projects the number of channels expected to be supported by a "proposed digital MVDS design" as "128 to 384 in 1 GHz" (Teledesic Ex Parte Presentation, March 16, 1995, p. 6) or "approx 300 channels in 1 GHz" (Teledesic Ex Parte Presentation, March 16, 1995, p. 11). First, the 40 GHz MVDS system uses a frequency plan which requires 2 GHz, not 1 GHz *per system operator*--any reference to any number of channels in "1 GHz" is simply in error. Secondly, and independent of the first error, the more likely value (and the value advanced by the RA) is close to 128-channel service with 2 GHz per operator as noted by Philips Microwave (Philips Microwave, "Microwave Video Distribution Systems--The 1994 Position," November 16, 1994, p. 3, p. 23) given that only MPEG-2 compression allows bit rates of approximately 8 Mb/s for "rapid movement" programming material such as sports.

Both the RA and CellularVision agree that a minimum of 1 GHz of bandwidth deliverable to each subscriber is necessary to compete with cable since this bandwidth is deliverable by cable today. Further, as the RA has noted, 2 GHz of spectrum per service provider is required in the 40 GHz MVDS system to deliver a 1 GHz service bandwidth to individual subscribers and to thereby create "the possibility of head-on competition to cable" (p. 5) on a bandwidth basis. 28 GHz LMDS can deliver the same cable-competitive 1 GHz service bandwidth to individual subscribers with only 1 GHz of spectrum per service provider due to the inherent difference in the efficiencies of the 28 GHz LMDS and the 40 GHz MVDS system designs.

Indeed, Philips acknowledges that digital MVDS is dependent on future technology development when it comments that "what is required is a low cost QPSK transmitter." (Philips Microwave, "Microwave Video Distribution Systems--The 1994 Position," November 16, 1994, p. 3). The implication is clearly that one does not now exist--a point with which CellularVision agrees.

AFFIDAVIT OF ERIC N. BARNHART, P.E.

I, Eric N. Barnhart, declare as follows:

1. I am currently a member of the Research Faculty of the Georgia Institute of Technology and Chief of the Communications and Networking Division, Georgia Tech Research Institute.

2. The attached paper, "The U.K. Radiocommunications Agency and CellularVision concur: LMDS is Not Viable in the Frequency Bands Above 40 GHz," is the result of my own independent research and analysis and does not represent the views of the Georgia Institute of Technology, which has not expressed an opinion in the 40 GHz Rulemaking proceeding.

3. Except for those factual matters of which official notice may be taken or which are matters of public record, the statements made in the attached paper are true, complete and correct to my personal knowledge.

I declare under penalty of perjury that the foregoing is true and correct.

ENB

Eric N. Barnhart, P.E.

District of Columbia

Subscribed and sworn before me, this 18th day of April, 1995

Mary K. Kane

Notary Public

My Commission expires: June 14, 1999

Georgia Institute of Technology
Georgia Tech Research Institute

BIOGRAPHICAL SKETCH

ERIC N. BARNHART, P.E.
Division Chief
Communications and Networking Division

Education

M.S.E.E., Georgia Institute of Technology	1985
B.E.E., Auburn University	1982

Employment History

Georgia Institute of Technology	
Chief, Communications and Networking Division	1993-Present
Director, Communications Laboratory	1991-1993
Associate Chief, Communications Systems Div.	1989-1990
Head of Communications Countermeasures Branch	1988-1989
Senior Research Engineer	1990-Present
Research Engineer II	1986-1990
Research Engineer I	1983-1986
Martin Marietta Aerospace, Orlando Division	
Engineering Aide	1979-1981

Experience Summary

Has technical oversight, administrative, and budget responsibility for the Communications and Networking Division. Presently conducts and oversees sponsored programs in broadband systems, wireless communications, commercial telecommunications and CATV systems, and military C3I systems and countermeasures. Responsible for the development and management of GTRI systems and technology programs related to these research areas. Is a member of the staff of the Georgia Center for Advanced Telecommunications Technology (GCATT). Currently is involved in the investigation of indoor propagation and the development of Personal Communications Network (PCN) services and equipment. Is also currently involved in development of interactive cable system trial for distance learning. Recently involved in the development of adaptive, spread-spectrum communications systems and techniques. Has also investigated co-site interference mitigation techniques. Has conducted vulnerability analysis and testing of multichannel secure communications systems for tactical and strategic applications. Has experience in the performance analysis and operational testing of intercept systems, and foreign equipment exploitation and analysis. Has experience in the analysis and computer modeling of coded, spread-spectrum digital communications systems to investigate system vulnerability with respect to interception and disruption by jamming. Has experience with propagation analysis/modeling from HF through millimeter-wave frequencies, threat evaluation and wideband signal processing. Has hardware design experience with discrete digital systems, hardware/software development experience with microprocessor based systems and RF communications systems from HF through millimeter-wave bands. Also has worked on systems integration, calibration, and testing of millimeter-wave radar seeker/guidance systems, direction finding systems and temperature control systems. Active as a consultant to government and industry.

Current Fields of Interest

Wireless/personal communications; broadband interactive systems; telecommunications/economic development; networks for enterprise integration, distance learning and telemedicine; multimedia and client-server systems and architectures; military communications; communications privacy/security; telecommunication systems and networks; co-site interference reduction techniques; data communications; lightwave communications; intercept/surveillance systems and techniques; countermeasures systems and techniques; communication system vulnerability; modeling; simulation; signal processing.

Registrations and Special Honors

Registered Professional Engineer, Georgia
General Chairman, 1993 National Telesystems Conference
Steering Committee and Technical Program Committee, 1994 and 1995 National Telesystems Conference--The Microwave Systems Conference
Wireless Technology Consultant, Sun Features/L.A. Times Syndicate
National Science Foundation Small Business Innovative Research (SBIR) Proposal Review Board in Communications and Networking
Scientific Advisory Board - International Tele-Marine Corporation
Telecommunications Technology Consultant to Caribbean Association of National Telecommunications Organizations (CANTO)
Member: IEEE, IEEE Communications Society, Communications Systems Engineering Committee, Radio Communications Committee, Network Operations and Management Committee, Vehicular Technology Society, Aerospace and Electronic Systems Society; Society of Photo-Optical Instrumentation Engineers; Association of Old Crows; Armed Forces Communications Electronics Association; Tau Beta Pi, Eta Kappa Nu; ITS America
Federal Communications Bar Association (non-voting member)
Georgia Institute of Technology Research Advisory Council
President's Research Advisory Council, Georgia Institute of Technology
Technology Advisory Committee, Atlanta Educational Television Cooperative
National Security Industrial Association Committee on C3I
Listed in American Men and Women of Science
Listed in Who's Who Worldwide Registry of Business Leaders

Major Reports and Publications

1. "An Analysis of Millimeter-Wave Wireless Local Area Networks for LPI/AJ Command Post Communications," Proceedings of the 1993 Military Communications Conference, Boston, Massachusetts, October 1993, coauthor
2. "Distance Learning Via a Caribbean Teleconference Network," Record of the CANTO 1993 Conference and Trade Exhibition, Oranjestad, Dutch Caribbean, June 1993
3. "A Proposed Vocational Education Network: Training, Economic and Technical Implications," Proceedings of the 15th Pacific Telecommunications Conference, Honolulu, Hawaii, January 1993
4. "Trends in Multipath Delay Spread from Frequency Domain Measurements of the Wireless Indoor Communications Channel," Proceedings of the Third International Symposium on Personal, Indoor and Mobile Radio Communications, Boston, Massachusetts, October 1992, coauthor
5. "Mathematical Expressions and Algorithms for Cell Evaluation Tool," Final Report, Project A-9065-200, September 1992, coauthor
6. "Interim Technical Report Number 1: Experimental Licenses KK2XBA and KK2XBB," Interim Report, Federal Communications Commission, August 1992, coauthor
7. "Georgia: Well-Positioned for the Telecommunications Revolution," Computer Currents Magazine, Vol. 4, No. 8, August 1992
8. "Prototype Implementation of an EHF Switched-Beam Array Controller," Final Report, Project A-8200, August 1992, coauthor
9. "Propagation Characterization in Support of BellSouth Personal Communications Services Development," Final Report, Project A-9041, April 1992, coauthor
10. "Propagation Measurements in Support of Hitachi Wireless Communications Model Development," Final Report, Project A-9065-100, March 1992, coauthor
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BY FAX AND POST

Mr William F Caton
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The Federal Communications Commission
1919 M Street NW
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Washington DC
20554 USA

Tel: 0171 215 2111

Date: 7 March 1995

RECEIVED
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FCC MAIL ROOM

Dear Mr Caton,

UK Radiocommunications Agency comments on Cellularvision submission to FCC NPRM dated 30 January 1995 entitled " LMDS is not viable in the frequency bands above 40 GHz"

I understand that the FCC would welcome the Radiocommunications Agency comments on the Cellularvision submission, in response to your recent Notice of Proposed Rule Making , entitled "LMDS is not viable in the frequency bands above 40GHz ". Your name has been given to me as the person to write to in this context. If this is not the case would you please be good enough to pass it on to the appropriate person.

It seems your deliberations concern inter-alia the relative merits of 28GHz and 40GHz for local multipoint video distribution services (LMDS).

We have studied the Cellularvision Report and, before offering more detailed comments on those particular areas of the report which deal with the European situation and which reference the Report of the UK 40 GHz Working Group (November 1993), we would firstly like to say that,

i) by any objective engineering considerations on this matter , what works or can be made to work at 28GHz will work or can be made to work at 40GHz, and,

ii) that it is not in doubt that larger coverage areas are possible at lower frequencies than 40GHz , for example at 29 Ghz, due primarily to the increase in atmospheric losses and rain attenuation with increasing frequency.
By way of a simple comparison, our calculations show that when only atmospheric losses and rain attenuation (rain zone G) are taken into account,

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with other important system parameters held constant e.g. 64 degree sector antenna, the coverage distances at which a C/N of 12 dB is achieved for the 99.9% and 99.7% time availablities are as follows;

Availability	29GHz	41.5GHz
99.7%	7.2 km	4.5 km
99.9%	5.35 km	3.4 km

Furthermore, you will not need reminding that selective use of engineering information, out of context, can be misleading.

The following more detailed comments are offered in order to clarify the European situation and the references by Cellularvision to the UK 40 GHz Working Group Report:-

1) The CEPT has harmonised the band 40.5 to 42.5 GHz for MVDS through Recommendation T/R52-01 in 1990. Since then 11 countries have implemented the recommendation, 8 countries plan to and 2 will not. Implementation means allocation of the band for MVDS.

2) Whilst we are not able to speak for other European countries, in the UK 40 GHz MVDS use has been dependent on the release of Local Delivery Licence (LDO) franchises by the Independent Television Commission. The LDO licence was introduced to be "technology neutral" such that cable operators would have freedom within their franchise to use cable and/or 40 GHz MVDS in their network architecture. Furthermore the performance specification MPT1550, facilitating the type approval of 40 GHz equipment, was not published until September 1993. Therefore it is not correct to state that cable is being offered due to the inability of 40 GHz MVDS to serve subscribers; the legislation gives our Local Delivery Operators the choice, where previously they were constrained to use cable.

3) The first such franchise was awarded to Eurobell for West Kent in August 1994. They have indicated that they will implement a digital MVDS system at 40 GHz covering 33,000 (~1/3) of the homes in the franchise area, comprised of those in outlying villages and smaller towns.

4) The reconvened 40 GHz Working Group, chaired by the Radiocommunications Agency, is now addressing the requirements and specification for digital MVDS including interactive/back-channel issues. No firm decisions have been made but clearly a return path is necessary, with possibilities of it being located in-band, overlaid in another frequency band or via twisted pair. Therefore the potential

for interactivity is certainly not bleak, however it is important to note that the requirement for the return path was not identified as important by potential operators/industry during the development of the analogue MVDS specification (MPT1550). The main driver then was a low cost one way video service which was alternative to and cheaper than cable, utilising existing satellite type indoor receiver decoders. However due to timing and economic considerations over the release dates of the new franchise areas, digital MVDS is now more likely to be implemented than analogue.

5) It has always been recognised that the size of MVDS cells at 40 GHz is considerably reduced during rain fades. Therefore 40 GHz is better suited to lower rain rate climates, whether in Europe or the Americas. We note that there are large areas of North America which have similar low rain rates to Europe. Therefore we do not agree with the sweeping statement that 40 GHz MVDS is not viable in US climates. A similar consequence with respect to the rain faded coverage area is the availability being specified by Cellularvision of 99.9% time (~9 hours/year) which is higher compared to the UK criterion of 99.7% time (~27 hours/year). This is one of the many reasons that the performance/cost comparison made against the UK system is not valid.

6) The 40 GHz Working Group report in its general statement on page 6, regarding transmission over a few kilometres, has to be read in context. It was recognised that with the improvements possible in semiconductor technology, for RF power generation and receiver noise figures at 40 GHz, increased performance would provide increased range. The MVDS link budget in our report uses rain attenuation figures based on ITU-R rain zone G, giving 7 mm/hour for 99.7% availability and not 2.1 mm/hour as wrongly stated in the Cellularvision report. (7 mm/hr gives ~2.1 dB/km). To put this into perspective, the report gives an assessment of the distribution of average annual UK rain fade events, indicating that for 99.7% availability there would be approximately 300 fades each of duration 30 seconds reducing to 40 fades per year exceeding 4 minutes.

7) We do not agree with the parameters used in the assessment of the link budget in Table 1 of the Cellularvision submission. 40 GHz MVDS planning uses an eirp per channel of 8 dBW using the 64° sector coverage horn antenna, and not 2 dBW as stated. The receive antenna gain is at least 32 dBi and not 29 dBi as stated, this value being already achievable in production quantities for 38 GHz fixed link equipment. Our C/N for planning purposes has been 12 dB and not 16 dB as stated. The result of the use of these incorrect planning parameters is to further degrade the 40 GHz coverage distance calculated as compared to 29 GHz. Similarly the table assumes the same availability of 99.9% time, whereas we have set our availability at 99.7% time in line with the Broadcasting Satellite Service, thus further distorting the 40 GHz scenario. In

any objective comparison of two frequency bands, it is necessary to compare like with like; clearly Cellularvision have not done this in their submission.

8) The use of the 64° sector coverage antenna was chosen to maximise spectrum efficiency, providing essentially circular coverage from the edge of the coverage area while under rain faded conditions at the availability defined of 99.7% time. Further benefits accrue from this antenna compared to an omni, for example in the choice of transmitter location anywhere on the cell boundary and in its directivity allowing reduced frequency re-use distance. It was not chosen for reasons of sidelobe suppression, cross polarisation, oscillator stability, phase noise or power combining limitations as stated on page 13.

9) The frequency re-use figure of 20 to 30 km was thought judicious as a first approximation for initial planning exercises in the absence of detailed propagation measurements at 40 GHz. Obviously with careful selection of transmitter locations, terrain screening and azimuthal angle on the transmit antenna, better re-use will be possible in practice. Initial indications from the UK's propagation experiments point to there being significant enhanced propagation clear air effects. Therefore our cautious first approximation will be modified as appropriate when the propagation results are available. We believe this to be a responsible way to manage the planning of a broadcast service to the level of quality and availability required.

10) UK manufacturers have indicated that it will be quite feasible to make HEMT MMIC devices able to provide the filtering and power combining necessary to feed one 64° antenna per transmitter. Using a modular approach, a given percentage of redundancy in the form of standby channels will be available, rather than having two identical TWTAs, with one on permanent hot-standby. The whole concept of 40 GHz has been to keep the cost down by utilising existing standard low cost indoor satellite receiver decoders. This continues to be our philosophy for digital MVDS where we intend to adopt the MPEG2-DVB-S system parameters.

11) The UK 40 GHz MVDS specification uses 29.5 MHz channel spacing and 26 MHz bandwidth for one reason only. This is to be compatible with existing low cost satellite indoor receiver decoders. The 4 group 32 channel plan has been maximised to these parameters using frequency interleaving and orthogonal polarisation between adjacent coverage areas. The 20 MHz bandwidth used by Cellularvision is again not a valid comparison, the UK 26 MHz value being due to the increased necessary bandwidth for frequency modulation of PAL/I encoded video rather than NTSC.

12) The recognition in our report that 40 GHz MVDS cannot compete with cable was in the context of analogue one-way broadcasting compared with broadband cable / telephony overlay / optical fibre possibilities for the future. Clearly with 2 GHz of spectrum available at 40 GHz, with digital compression techniques, multiprogramme

and interactive back-channel possibilities, there is the possibility of head-on competition to cable, particularly when one looks at costs. Previous UK comparisons of cost have been between 40 GHz MVDS and cable. Comparisons with equivalent radio systems at lower frequencies will always favour the greater coverage system, however this is not the issue in Europe where lack of spectrum has resulted in the agreement that the long term home for MVDS is at 40 GHz. For the UK cable operators assessing the viability of 40 GHz versus cable, they will be concerned with the breakpoint in terms of number of homes to serve, at which the cost of MVDS falls below the equivalent cable cost. Our original costings for analogue indicated that this point is reached with communities of fairly small number i.e. ~ 400 to 600 homes depending on penetration of 33% or 50%. Another point to bear in mind is that the cost penalty in choosing 40 GHz rather than 29 GHz becomes a small percentage increase when looking at total system costs. This total cost includes all elements in the cable operation such as programme generation / capture, subscriber management, marketing, encryption, signal distribution, civil engineering costs, etc.

13) We are surprised at the conclusion that frequency re-use is not possible at 40 GHz but is at 29 GHz. For reasons stated above, the channel plan has been maximised to ensure best use of the spectrum in four channel groups within the band in the analogue broadcasting scheme. Clearly the interleaving of orthogonally polarised return paths would increase the spectrum efficiency within each cell, however we have yet to see any technical papers relating to the Cellularvision concept, demonstrating the feasibility at 29 GHz, particularly with respect to the reliance on uncharacterised specular reflections within the propagation path. In engineering 40 GHz MVDS, the 40 GHz Working Group has understood the requirement for line-of-sight reception, with the recognition that foliage is a problem at 40 GHz similarly to 29 GHz, necessitating MATV reception in those houses which cannot see the transmitter. It is our view that 40 GHz will be made to work within Europe and that is possesses very similar attributes to a 29 GHz system, albeit with reduced coverage due to rain and atmospheric absorption. Any frequency re-use distance which can in reality be achieved at 29 GHz can obviously be scaled to 40 GHz, assuming planning / system parameters and geometry are held constant.

To Conclude :-

- We believe that cost comparisons between 29 and 40 GHz are not valid in the UK deployment scenario. MVDS is being offered to cable operators as an alternative delivery medium. In cost terms it can serve equivalent cabled areas at a lower cost given the size of currently available 40 GHz coverage areas. Technology improvements will increase the size of these coverage areas. With digital multiprogramme MPEG2 and efficient modulation and channel coding techniques, very similar channel capacities to digital cable will be available to the subscriber.
- Our initial frequency re-use figures were conservative due to concern over anomalous propagation at the level of availability being defined. More detailed

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planning, taking into account the inherent directivity advantages of the 64° antenna and the reduced protection ratios possible for digital compared to analogue signals will, together with the results of the propagation trials, give an improved re-use distance figure.

- Further development of the total cellular planning concept, as espoused by Cellularvision, taking into account the above refinements, would see an effective alternative to 29 GHz being viable using directional transmit antennas at 40 GHz. This is in a band where 2 GHz of spectrum is exclusively available and which is planned without the reliance on orthogonal polarisation frequency interleaving via random reflective paths, which is a technique that the UK would not have sufficient confidence in supporting until wider operational trials had quantified its performance and reliability, particularly in terms of return paths at 99.9% availability.

I hope the above is of use in your deliberations. If we can be of any further assistance please let me know.

I am copying this letter to Mr Reinhart and Mr Ghazvinian in the USA, and Mr Couillard in Canada, with whom we have been in discussion with on the MVDS frequency question.

Yours sincerely,

Keith Whittingham

Keith Whittingham
Head of Television Broadcasting Section

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